APPENDIX H

RESEARCH NEEDS

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Exhaust Emissions

The ARB has an active research program to determine exhaust emissions from engines that it regulates. Existing and future exhaust emission control standards will continue to require that manufacturers reduce emissions from the small off-road engines found in leaf blowers. Staff conducts periodic reviews of technology to determine whether further emission reductions are possible. For example, the ARB has recently awarded a contract to the Southwest Research Institute to conduct research entitled “Particulate Emissions from Marine Outboard Engines, Personal Watercraft and Small Off-Road Equipment.” The objectives relevant to leaf blower technology are (1) to measure the emissions from two-stroke engines used in small off-road equipment, with an emphasis on PM emissions and polycyclic aromatic hydrocarbon levels; and (2) to determine particle size distribution and mutagenic toxicity of the PM. The contractor will obtain and test five engines typically used in leaf blowers or similar off-road equipment, and staff have recommended that engines used in leaf blowers be among those chosen.

In addition to this study, staff has identified investigation into small off-road engine deterioration as an area for future research; engine deterioration causes emissions to increase with engine usage. In general, research into annual usage data, both for the leaf blower equipment and for the operator, would be helpful. The estimated annual usage in the inventory may be lower than actual usage, and may not correlate well with how long an operator, commercial or residential, uses the equipment throughout the year.

Fugitive Dust

ARB staff found a fundamental lack of information on the nature and quantity of fugitive dust blown, or resuspended, by leaf blowers. Empirical data are needed, however, as calculations only go so far. Any study would need to consider a large number of variables, such as substrate, humidity, seasonality, and type of materials being moved by the leaf blower. Ideally, as part of a future research project, one would want to first quantify the emissions in actual use by: (1) inventorying the types of surfaces cleaned by leaf blowers statewide, and by air district, (2) determining the silt loading for surfaces that are cleaned, and (3) performing source testing to determine the amount of PM30, PM10 and PM2.5 entrained in the air, and to determine the "exposure envelope" associated with leaf blower usage. This information could then be used to calculate more accurate estimates of dust associated with leaf blower usage.

In addition to quantifying emissions, it would also be important to determine what is in the dust. This information would not be applicable only to leaf blowers, but would reflect what is in dust that is resuspended by wind from

any source. Presently, chemical speciation data are available for sources such as paved and unpaved roadways. For leaf blowers, we should also examine the make-up of dust from lawns, sidewalks, parking lots, and flower beds. In addition to chemical speciation, it would also be useful to analyze the dust for the presence of herbicides, pesticides, bacterial endotoxins, and other toxins.

Noise Emissions

The investigation and reduction of noise emissions is not part of the ARB's authority or mission. Traditionally, noise control and abatement has been a local function, although a state Office of Noise Control did exist for a short time; the Office was housed within the Department of Health Services. Quantifying noise exposures of landscape and gardening workers might be conducted as a part of a larger ARB effort aimed at better understanding the leaf blower population and annual hours of use. Otherwise, most noise related research would be better conducted by other state agencies.

Quantify the number of Californians affected by noise and noise exposure levels. The purposes of this study would be two-fold: First, to assess the number of workers who are exposed to leaf blower noise, the number of hours they are exposed daily, and their daily noise dose and exposures. Second, to determine the number of people exposed non-occupationally to leaf blower noise, average noise exposures, frequency of exposure (e.g., daily, weekly), and how they are affected (e.g., annoyed, interference with sleep or communication). Agencies potentially responsible for this study would include ARB; the Office of Environmental Health Hazard Assessment; and the California Department of Health Services Occupational Health Branch.

Evaluate hearing loss in gardeners, emphasizing those who use leaf blowers as a part of their work. The purpose of this study would be to evaluate, more specifically, the incidence of noise-induced hearing loss in occupationally exposed gardeners. Non-occupational exposure to noise would also need to be assessed. Agencies potentially responsible would include the California Department of Health Services Occupational Health Branch.

Exposure Data and Potential Health Impacts

Exposure data are needed to determine potential health effects, particularly from CO, particulates, and noise. On December 27, 1999, ARB was mailed a redacted copy of a 1995 report entitled "Evaluation of Chemical Emissions From White Consolidated Industries Products"1 (WCI). The WCI report was prepared for Poulan/Weed Eater to determine operator exposure levels for several chemicals that are present in handheld gasoline-powered

1 Batelle. Evaluation of chemical emissions from White Consolidated Industries products, final report. Prepared for Poulan/Weed Eater, Division of WCI Outdoor Products, Inc. Batelle: Columbus Operations. October 1995.

equipment exhaust emissions, specifically chemicals that are listed under California's "Proposition 65" law as either carcinogens or reproductive or developmental toxins. Batelle, which prepared the WCI report, measured breathing zone concentrations during operation of a leaf blower, three chain saws, and a string trimmer and calculated user exposures. Before sending the report to ARB, however, all data relating to the chain saws and string trimmer were blacked-out.

The WCI report presents the only data on operator exposures from leaf blowers known to ARB at this time. As noted, exposure data are crucial for determining health impacts. Although the WCI report was received too late for discussion in the body of the leaf blower report, the following summary and analysis of the results of the WCI report are included in this appendix.

The WCI study measured breathing zone exposures of operators of certain power equipment to six toxic chemicals: formaldehyde, acetaldehyde, benzene, 1,3-butadiene, toluene, and carbon monoxide. The leaf blower tested was a consumer model with an engine displacement of 32 cc and engine horsepower of 0.9; the blower was run at full throttle for 30 minutes in each of two tests. Concentrations of the six toxic chemicals were measured and user exposures were calculated based on specified assumptions. The WCI report concludes that "[m]easured concentrations and calculated user exposures are below all existing concentration standards and Prop 65 allowable exposures. . . . Consequently, operator exposures to the target chemicals from normal use of WCI power equipment do not convey significant health risks as established under Prop 65."

Study limitations include a small sample size and potential bias towards conditions that could minimize risk calculations. As only one leaf blower was tested, the results cannot be assumed to represent all leaf blowers. As only two samples were collected from the leaf blower, the results are likely not representative of breathing zone concentrations that would be experienced by a variety of operators. Conditions during the test that could minimize measured concentrations, and thus underestimate risk, include 10 mph winds, one start-up per test (emissions are higher during start-up), and the use of a new, properly tuned leaf blower. Typically, older equipment emits more pollutants. In addition, the user exposure is calculated by assuming that 30-minutes is the maximum time of exposure for all users, and Batelle represents this as a "worst case" exposure. It is more likely that this represents a "best case" scenario for exposure, however, and that 8-hours of exposure would more likely represent a "worst case" scenario. Given these limitations, the WCI report supports ARB's conclusion that additional research is needed to better understand operator exposures to hazards and provides further evidence for concern regarding operator exposures to exhaust emissions.

Table 1. WCI Report Calculated Daily Exposure Levels

Weed Eater model GBI-30V, 0.9 hp engine	Measured Conc. ($\mu g/m^3$)	Ambient Air Conc. ($\mu g/m^3$)	WCI Adjusted Conc. ($\mu g/m^3$)	WCI Calculated User Exposure (μg/day)	Standards (μg/day)
Formaldehyde	33.1, 28.1	22.6, 23.4	7.6	0.31	40*
Acetaldehyde	23.0, 22.2	12.3, 17.5	7.7	0.31	90*
Toluene	265, 144	2.0, 1.7	55.3	84	13,000+
Benzene	67.2, 45.2	0.84, 1.02	203	2.25	7*
1,3-Butadiene	0.92, <0.15	<0.15, <0.15	0.39	0.02	0.4*
Carbon Monoxide, ave.	3435, 6870	1145, <1145	4010	2005†	40000#
Carbon Monoxide, peak	29800, 43500	3435, 1145	34400	34400‡	458000**

†Assumes 30 minute exposure averaged over one-hour, in $\mu g/m^3$; an 8-hour exposure is assumed to be 250 $\mu g/m^3$, or 2005 $\mu g/m^3$ divided by 8 hours.
‡Measured peak in units of $\mu g/m^3$
*Prop 65 No Significant Risk Level
+Prop 65 Acceptable Daily Intake Level
#U.S. EPA One Hour Ambient Air Quality Standard (The California one hour standard is 23,000 $\mu g/m^3$)
**ACGIH Workplace Short Term Exposure Limit (15 min)

A draft research plan to begin assessment of potential health impacts of leaf blowers on operators and the public-at-large is included herein as a starting point to assess tasks and costs:

Assessing Potential Health Impacts of Leaf Blowers on Operators and the Public-at-Large

This draft, proposed research plan would address two issues related to leaf blower usage in California: First, what is the nature and quantity of fugitive dust resuspended by leaf blower usage; and second, what are the exposures to carbon monoxide, other exhaust emissions, and fugitive dust experienced by leaf blower operators? The proposed research does not include research into noise exposure, although the study could be expanded with outside expert assistance, as ARB does not have a mandate to study noise. The study also would not directly assess exposures experienced by bystanders in the vicinity of someone else using a leaf blower, although the data gathered could be used to make some preliminary estimates regarding these exposures. The estimated cost of the study is $1,100,000.

Task 1 - Population and activity survey. $50,000. Determine the population of leaf blowers, by type (backpack engine-powered, wheeled engine-powered, handheld engine-powered, handheld electric), by air district. Determine usage

patterns, how many are used by homeowners and how often, and how many by professional gardeners and how often. Also determine the amount of time each leaf blower is used versus the amount of time each person (including non-operators on a gardening crew) are exposed to leaf blower use. This task would involve the development of a survey instrument and may involve the use of data loggers.

Task 2 - Methodology development for measuring and calculating fugitive dust (particulate matter) emissions and exposure assessment. $50,000. This task would build on previous data on measuring and calculating emissions, but would involve some new methodology as no previous studies have measured fugitive dust resuspended by leaf blowers. As leaf blowers are often used at the same time as other lawn and garden equipment, this task will include differentiating between emissions from leaf blowers and other equipment.

Task 3 - Field study to collect data on exhaust and fugitive dust generation and exposures by operators. $800,000. The study has several facets:

Task 3a - Dosimetry of operators to measure CO and other exhaust emissions exposures. Could also include audiodosimeters if noise dose is being measured. Operators participating in the study would keep journal records of activities while working with lawn and garden equipment.

Task 3b - Measure silt loadings for representative sites based on where leaf blowers are used, during different climate conditions and/or seasons, and in different regions of the state.

Task 3c - Perform fugitive dust emissions sampling and sample collection at selected sites, during selected seasons; data are to be used to estimate both personal exposures, emissions factors, and aggregate daily emission rates.

Task 4 - Sample chemical analysis. $100,000. Actual cost depends on number of samples and chemical species analyzed. Cost assumes 50 samples at $2,000/sample. Study would analyze samples for elements and ions and organic species, such as vegetative detritus, fecal matter, pollen, mold spores, and endotoxins.

Task 5 - Data analysis. $30,000. Analyze data and prepare emissions estimates. Include size-segregated PM emissions for emissions inventory and for personal exposure assessment.

Task 6 - Quality assurance. $30,000. Determine accuracy of subjects in recording leaf blower usage in daily journals, proper use of dosimetry equipment, and chemical and data analyses.

Task 7 - Reporting and final report. $30,000.